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Northern Red Oak Regeneration

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NORTHERN RED OAK REGENERATION AFTER PREHERBICIDED CLEARCUTTING AND SHELTERWOOD REMOVAL CUTTING

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The failure of northern red oak (*Quercus rubra* L.) to regenerate in upland oak forests on good sites in southern Wisconsin and similar areas in adjacent States is a serious silvicultural problem (Johnson 1976). Unfortunately, reliable methods of obtaining adequate oak regeneration have not been developed yet (Sander 1979). Therefore, oak stands in this region with known histories of cutting and regeneration development are potentially important sources of information on the oak regeneration process.

This report documents the status of northern red oak reproduction after final harvest cutting in the Hardies Creek Timber Harvest Forest[1] in Trempealeau County, Wisconsin. Two of the stands were managed under two variations of the shelterwood system for 20 years preceding the final harvest; the third stand was clearcut after the understory was herbicided but received no cutting for 20 years preceding the final harvest.

FOREST CHARACTERISTICS

The 60-acre Hardies Creek Timber Harvest Forest lies within the unglaciated or "driftless" area of southwestern Wisconsin. The forest is situated on mainly east to northeast aspects, and slopes range from about 20 to 45 percent. The soil is Hixton loam formed on loamy sandstone residuum underlain by cemented sandstone bedrock; the solum ranges from 20 to 40 inches deep (Langton 1977). Site index for red oak is about 70.

The oldest stands in the forest were 106 years old at the time of the latest harvest (1974), even aged, and dominated by northern red oak. Black oak (*Quercus velutina* Lam.) and white oak (*Quercus alba* L.) dominated on some upper slopes. In the lower tree canopy, shagbark hickory (*Carya ovata* (Mill.) K. Koch) and black cherry (*Prunus serotina* Ehrh.) were the most important species; the latter occurred primarily as understory seedlings and saplings and few developed into sawtimber-size trees. Other subordinate tree species included American elm (*Ulmus americana* L.), mountain maple (*Acer spicatum* Lam.), boxelder (*Acer negundo* L.), and paper birch (*Betula papyrifera* Marsh.).

A dense shrub canopy is a conspicuous feature of much of the forest; predominant species are American hazel (*Corylus americana* L.), gray dogwood (*Cornus racemosa* Lam.), and common blackberry (*Rubus allegheniensis* Porter). In some areas, interrupted fern (*Osmunda claytonia* L.) and lady fern (*Athyrium felix-femina* L.) form a nearly continuous 3-foot tall ground layer. The possible origin, successional status, and other characteristics of southern Wisconsin oak forests have been discussed elsewhere (Curtis 1959, Auclair and Cottam 1971, Loucks and Schnur 1976, Braun 1967, Marks 1942).

In some unmanaged portions of the forest total basal area exceeds 130 square feet per acre, 80 percent or more of which is northern red oak. Mean stand diameters of the overstory range from about 14

[1] *A State-owned tract on which demonstration and research projects are being carried on cooperatively by the Wisconsin Department of Natural Resources, the office of the Extension Forester at the University of Wisconsin, and the USDA Forest Service.*

to 16 inches d.b.h. Northern red oak is poorly represented or nonexistent in sapling and small pole-size diameter classes. Earlier studies of this forest have shown that although red oak seedlings under mature stands may exceed 7,000 per acre (Johnson 1974), few grow beyond 6 to 8 inches in height due to severe competition from ferns and shrubs (Scholz 1955). Thus, populations of small red oak rise and fall cyclicly, depending upon acorn crop and environmental conditions after seedfall. In the even-aged management of oaks, advance reproduction of this size has been considered inadequate for meeting stocking needs after final harvest cutting (Sander *et al.* 1976).

STAND HISTORIES

Shelterwood A.—Three shelterwood cuttings were made in this 5.4-acre stand prior to the final removal cut in 1974 at stand age 106. The first cut (preparatory cut) was made in 1952 at stand age 84 and reduced basal area from 123 to 103 square feet per acre (table 1). Mean stand diameter before and after this cut was between 14 and 15 inches d.b.h.

The second cut (seed cut) was made in 1962 at stand age 94 and reduced basal area to 75 square feet per acre. Just before this second cut, red oak reproduction averaged 1,500 stems per acre with 30 percent of milacre sample plots containing one or more seedlings; most of these were less than 1 foot tall. Number of seedlings of all other tree species averaged 3,480 per acre.

The third cut (second seed cut) was made in 1968 at stand age 100 because the first seed cut was too light. Basal area was reduced to 60 square feet per acre. In all three shelterwood cuts, removals were concentrated in the smaller diameter classes present. The final cut was made in the spring of 1974 during which all trees 2 inches d.b.h. and larger were felled or girdled. No inventory of reproduction was made immediately before the final removal cut.

Shelterwood B.—The combination preparatory/seed cut was made in this 6.5-acre stand in 1959 at stand age 91 and reduced basal area from 96 to 63 square feet per acre (table 1). Mean stand diameter was 16.0 and 16.5 inches d.b.h. before and after cutting, respectively. Most of the trees removed were in the smaller diameter classes present. In the final removal cut made early in 1968 at stand age 99, all trees 2 inches and larger were felled or girdled.

A reproduction survey just after the preparatory/seed cut in the spring of 1960 showed 552 seedlings per acre—all 18 inches or less in height. Tree reproduction of all other species averaged 396 per acre, with shagbark hickory and black cherry predominating. White oak, American elm, and paper birch were also present. The tallest reproduction was black cherry, American elm, and paper birch, which collectively averaged 57 inches in height. However, only 22 percent of milacre sample plots were stocked with any species of tree seedlings.

Seven growing seasons after the preparatory/seed cut, red oak reproduction averaged 2,600 trees per acre and were present on 58 percent of milacre plots. The average height of these trees was 10 inches and height ranged from 3 to 91 inches. All other tree reproduction averaged 417 stems per acre and were present on 38 percent of milacre plots. This reproduction averaged 69 inches in height and consisted mostly of shagbark hickory, black cherry, white oak, and paper birch.

Table 1.—*History of stand removals and basal areas*

Year	Stand age	Shelterwood A	Shelterwood B	Preherbicided clearcut	Type of removal
		Basal Area Per Acre (ft^2) Before/After Removals			
1951	83	—	—	137/103	Thinning
1952	84	123/103	—	—	Preparatory cut
1959	91	—	96/63	—	Preparatory/seed cut
1962	94	[1]*/75	—	—	Seed cut
1968	100	*/60	—	—	Seed cut
1968	100	—	*/0	—	Final Harvest
1972	104	—	—	(Herbicided)	Understory[2]
1973	105	—	—	(Herbicided)	Understory[2]
1974	106	*/0	—	*/0	Final Harvest

[1]* = unknown basal area.

[2]Shrubs and trees <2 inches d.b.h. were removed.

Preherbicided clearcut.—In 1951 at stand age 83, basal area was reduced in this 5.9-acre stand from 137 to 103 square feet per acre (table 1). Mean stand d.b.h. was 14 inches both before and after thinning.

The understory of this stand was treated with 2,4,5-T in late summer of 1972 and any surviving understory vegetation was treated again in 1973. The acorn crop was moderately good in the fall of 1973, and seedfall was complete before the stand was clearcut in early spring of 1974 at stand age 106. No information is available on parent stand characteristics at the time of the clearcut.

REGENERATION AFTER FINAL HARVEST CUTTING

Trees and shrubs were inventoried in early spring 1979 on 32 4.3-foot-radius plots in each of the three stands. A 1/735-acre plot size was used because it is the "minimum tree area" for a tree 4.5 inches d.b.h. (Gingrich 1967). In other words, a tree 4.5 inches d.b.h. requires a minimum of 1/735-acre (1.36 milacres) of growing space. It is assumed that dominant or codominant trees average 4.5 inches d.b.h. when mean stand diameter is 3 inches (Sander *et al.* 1976). At or beyond a mean stand diameter of 3 inches, more than one codominant or larger tree would not be expected to persist within a 1/735-acre sample space. When trees reach 3 inches in mean diameter, their utilization of growing space can be evaluated using the central hardwoods stocking guide (Roach and Gingrich 1968). Thus, a 1/735-acre plot is an appropriate sampling unit that can be used to express the number of "unit-growing-spaces" occupied by tree reproduction that can be related to future stocking criteria.

Shelterwood A.—Red oak seedlings and seedling-sprouts averaged 506 per acre and were present on 316 unit-growing-spaces per acre (43 percent of plots) five growing seasons after the final harvest cut (table 2). Most of them were more than 5 feet tall (table 3), with the largest red oak per stocked plot averaging 8.8 feet. Largest competitors averaged 10.3 feet in height and included black cherry, shagbark hickory, mountain maple, paper birch, and a few clumps of red oak stump sprouts. Red oak was codominant or larger (i.e., at least as tall as the largest competitor on a plot) on 28 percent of plots. Shrubs occurred on 60 percent of plots and the mean height of the shrub layer was 6.6 feet. American hazel and gray dogwood were the predominant species. Red oaks at or above the mean shrub canopy level occupied 279 unit-growing-spaces per acre (38 percent of plots).

Shelterwood B.—Red oak seedlings and seedling-sprouts averaged 804 per acre and were present on 316 unit-growing-spaces per acre (43 percent of plots) 11 growing seasons after the final harvest cut. Most of them were more than 5 feet tall (table 3), with the largest red oak per stocked plot averaging 16.6 feet in height. Codominant or larger competitors averaged 19.8 feet in height. Red oak was codominant or larger on 184 unit-growing-spaces per acre (25 percent of plots). Shrubs occurred on 41 percent of plots and the mean height of the shrub layer was 6.6 feet. American hazel and gray dogwood were the predominant shrub species. Red oaks at or above the mean shrub canopy level occupied 301 unit-growing-spaces per acre (41 percent of plots).

Preherbicided clearcut.—Red oak seedlings and seedling-sprouts averaged 2,872 per acre and were represented on 617 unit-growing-spaces per acre (84 percent of plots) five growing seasons after the clearcut. Most of these trees were less than 5 feet tall

Table 2.—*Northern red oak seedlings and seedling sprouts after final harvest cutting*

Stand	Northern red oaks	Unit growing spaces occupied by N. red oaks	Mean height of codominant or larger N. red oaks[1]	Unit growing spaces occupied by a codominant or larger N. red oak[2]	Unit growing spaces occupied by red oak at or above mean shrub canopy level
	(Mean no./acre)		(Feet)	(Mean no./acre)	
Shelterwood A[3]	506	316	8.8	206	279
Shelterwood B[4]	804	316	16.6	184	301
Clearcut[4]	2,872	617	3.6	301	162

[1]Based on red oaks as tall or taller than the largest competitor tree per plot.
[2]Based on chi-square—differences betweeen stands were not significant (0.05 level).
[3]Eleven years after final harvest cutting.
[4]Five years after final harvest cutting.

Table 3.—*Northern red oaks seedlings and seedling sprouts by stand and height class (time since harvest cutting is 5 growing seasons for Shelterwood A and the clearcut and 11 growing seasons for Shelterwood B)*

(In number/acre)

Stand	Tree height class (feet)					
	<1	1 to 1.9	2 to 2.9	3 to 3.9	4 to 4.9	≥ 5
Shelterwood A	0	69	23	46	23	345
Shelterwood B	0	0	23	23	0	758
Clearcut	253	781	942	482	230	184

(table 3), with the largest red oak per stocked plot averaging 3.6 feet tall. Red oak was codominant or larger on 301 unit-growing-spaces per acre (41 percent of plots). However, with the sample size used, no between stand differences (0.05 level) in the proportion of plots stocked with codominant or larger red oaks could be demonstrated based on chi-square analysis.

Dominant competitors averaged 7.3 feet tall and their composition was similar to that of the shelterwood stands. However, in 1979, total density of competing trees and shrubs was visibly lower in the preherbicided clearcut than in either of the shelterwood-origin stands. Shrubs occurred on 38 percent of plots, and the mean height of the shrub layer was 5 feet. American hazel was the predominant species. Red oak seedlings and seedling-sprouts at or above the mean shrub canopy level occupied 162 unit-growing-spaces per acre (22 percent of plots).

The number of stump sprout clumps were not adequately inventoried after the final cut. However, they were expected to range from 18 in Shelterwood B to 46 in the clearcut, based on number of parent trees per acre before the final removal cut and the relation between frequency of sprouting and parent tree diameter (Johnson 1975).

DISCUSSION AND CONCLUSIONS

Neither shelterwood stand contained many red oaks less than 5 feet tall in contrast to the clearcut which contained a large population of red oaks less than 5 feet tall. Most of the red oak reproduction in the clearcut originated from the 1973 acorn crop. This suggests that the preherbicided clearcutting created more favorable conditions for seedling establishment and development than in Shelterwood A in which the final removal cut took place the same year. Moreover, the paucity of red oaks larger than 5 feet tall in the clearcut indicates that advance oak reproduction was either eliminated by the herbicide or was not present before herbiciding.

Minimum stocking required to regenerate these stands is 221 well distributed dominant or codominant trees per acre of acceptable species by the time the stand reaches 3 inches in mean d.b.h. (Sander *et al.* 1976). In the shelterwood-origin stands, this goal will not be attainable if total contributions to future stocking depend on the free-to-grow red oaks that are now present. However, other acceptable growing stock, including shagbark hickory and red oak stump sprouts, could compensate for deficiencies in advance red oak reproduction. Currently overtopped red oaks may be capable of emerging to positions of dominance but whether or not they will do so is unknown (Oliver 1978). The current number of codominant or larger red oaks per acre in the shelterwood-origin stands are nevertheless substantially higher than the number predicted to develop in an average clearcut at the same age (Johnson 1976).

An important ecological limitation to the shelterwood system as a method of increasing red oak regeneration in this region is the shrub layer, which increases in density as overstory density decreases (Auclair and Cottam 1971). In turn, as shrub density increases, tree seedling populations tend to decrease (Johnson 1976, Loucks and Schnur 1976). Thus, reducing overstory density by shelterwood cuttings might not create favorable conditions for establishment and development of oak reproduction unless the understory is also controlled (Sander 1979). This view is supported by the failure of red oak seedlings to develop in Shelterwood B following the large 1973 acorn crop.

In the preherbicided clearcut, adequate regeneration and ultimately complete utilization of growing space by red oaks may be potentially more realizable than in either shelterwood because of the reservoir of more than 1,500 2- to 4-foot tall seedlings per acre. Although relatively small, this reproduction is well distributed, and about 300 unit-growing-spaces per acre (41 percent of the plots) contain trees that are free to grow. Nevertheless, developmental success of red oak reproduction in this stand will depend on future growth rates of oaks in relation to growth rates and population density of competitors. If red oaks ultimately occupy an acceptable proportion of the stand, it may cause reconsideration of the assumption that obtaining red oak reproduction in advance of the final cut is necessary, at least in this ecological setting. However, such cuts would have to coincide with good acorn crops and competition would have to be controlled.

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Northern red oak (*Quercus rubra* L.) reproduction and competition are described 5 or 11 years after final removal cuttings in two shelterwoods and one preherbicided clearcut in southern Wisconsin.

KEY WORDS: *Quercus rubra* L., two-step shelterwood, four-step shelterwood, understory control, herbicide, 2,4,5-T.

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